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## PATENT SPECIFICATION

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### COMPLETE SPECIFICATION

#### Improvements in or relating to Sintered Bearing Metal

We, GENERAL MOTORS CORPORATION, a Company incorporated under the laws of the State of Delaware in the United States of America, of Grand Boulevard in the City of 5 Detroit, State of Michigan, in the United States of America (Assignees of ROBERT FRANCIS THOMSON) do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it 10 is to be performed, to be particularly described in and by the following statement:—

This invention relates to sintered bearing metal.

According to the invention sintered bearing 15 metal which is made by a powder metallurgy process contains at least 50% of copper by weight of the product and hard particles of aluminium oxide in a proportion between 0.25 and 15% by weight of the product.

From another aspect, the invention can 20 be regarded as sintered copper-base metal suitable for use as bearing material, made by a powder metallurgy process from a powdered mixture containing at least 50% by weight of 25 copper and containing hard particles of aluminium oxide, the latter being present in a proportion between 0.25% and 15% by weight of the mixture.

In the manufacture of sintered copper-base 30 metal for use as bearing material, the remaining ingredient or ingredients of, and the proportions in which they are present relative to copper in, the copper-base metal employed, are selected with regard to the particular use to which the 35 final bearing is to be put. The improvement in wear resistance obtained in accordance with this invention by including hard particles of aluminium oxide in sintered copper-base metal suitable for use as bearing material has been 40 found to be marked when the remaining metallic ingredient of the sintered copper-base metal product is substantially all zinc (up to 45% by weight of the product, the powdered mixture comprising copper-base metal and aluminium 45 oxide), nickel (up to 49%), lead (up to 30%)

or aluminium (up to 15%, particularly from 2 to 11%). Improvement in wear resistance is also obtained when the remaining metallic ingredient is iron (particularly between 1 and 11%).

The wear resistance of sintered copper-base metal containing between 1 and 3% of silicon is also improved. Small quantities of such elements as manganese, beryllium, cobalt and phosphorus, incidentally present in some of the commercially available forms of the above-mentioned substances, have been found to have no substantially deleterious effect on the performance of sintered copper-base metal product of the invention.

Particularly marked improvement in wear resistance is shown by sintered copper-base metal products in which copper forms more than 70% by weight; by products in which the remaining metallic ingredient is substantially all nickel in an amount between 2 and 15% by weight; and by products in which the remaining metallic ingredients are substantially all tin and nickel together, in proportions respectively between 1 and 13%, and 2 and 15%, by weight of the product. Tin can be included in the powdered mixture to be subjected to sintering in the form of commercially pure tin dust; alternatively, a bronze powder of appropriate composition can be employed instead of a powdered mixture of copper and tin. Nickel is most 50 suitably used in the form of a very fine powder obtainable by thermal decomposition of nickel carbonyl; alternatively, it can be used in the form of commercial electrolytic nickel powder.

Preferably the aluminium oxide is present in the sintered copper-base metal product in a proportion between 0.25 and 7.5% by weight; and particularly good results are obtainable by limiting the amount of aluminium oxide to between 1 and 5% by weight.

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Among the forms of aluminium oxide which can be powdered to give the requisite hard particles, are fused alumina, such as alundum (obtainable by fusing bauxite in the electric furnace); the impure aluminium oxide containing minor amounts of iron oxide and known as "Turkish emery"; corundum (native crystalline aluminium oxide); and tabular corundum (a high temperature calcined alumina). These 5 are conveniently employed in the form of —100 to —600 mesh powder; —250 to —350 mesh powders are usually the most suitable. Such materials are commercially available as Alundum 600x and Alundum 320B, Turkish 10 emery 320, corundum 300, and tabular corundum —100/—200.

In preparing the powdered mixture of copper-base metal and aluminium oxide, it is often advantageous to include a small amount, up to 20 6.5% and most suitably from 0.3 to 4% by weight, of finely divided graphite (80 mesh or finer).

A small amount, suitably from 0.3 to 2.0%, of powdered zinc stearate, which acts as a die 25 lubricant, may also be included in the powdered mixture; alternatively, powdered stearic acid can be used.

The copper-base metal powder (suitably of 30 60 to 325 mesh; and hydrogen-reduced copper of 150 mesh gives very good results as the copper ingredient of the copper-base metal powder), hard particles of aluminium oxide obtained by pulverising a suitable form of aluminium oxide, such as corundum, and 35 powdered graphite and zinc stearate (if their presence is desired), are thoroughly mixed, and briquetted at a pressure of 20,000 to 120,000 pounds per square inch (usually a pressure of 40,000 to 60,000 pounds per square inch is 40 convenient) in a die having a contour which is complementary to the bearing surface to be formed.

The green briquette is then sintered in an 45 inert atmosphere to form a structure having a controlled degree of porosity. Sintering times between 15 and 30 minutes, and sintering temperatures between 1300°F and 1950°F, for instance 20 minutes, at 1500°F, are satisfactory; however, these conditions are not critical, and 50 sintering may in some cases be carried out in four minutes, and in others it may be performed over a period of two hours.

As inert atmosphere, a mixture composed of 55 20% carbon monoxide, 3% hydrogen and 77% nitrogen, usually gives good results, as does a similar gaseous mixture consisting of 1.5% carbon monoxide, 1.5% hydrogen and 97% nitrogen. An atmosphere of dissociated ammonia may be employed. Of course, the 60 atmosphere used in any particular case will be selected with regard to the reactivity of the additional metallic ingredients present in the copper-base metal powder to be sintered; in some instances an atmosphere of hydrogen is 65 to be preferred, while in others a mixture of

nitrogen and hydrogen or methane can be used.

If the sintered metal product is one obtained from a powdered mixture in which nickel was present in unalloyed form, it is advantageous to carry out a solution treatment after the 70 sintering step and so improve the hardness and homogeneity of the product. This can be done by heating for 1 to 8 hours at 600°F to 1400°F in an inert atmosphere, or, better, by a method involving an initial heat treatment for 5 hours at 1400°F in an inert atmosphere, a water or oil quench, and a low temperature heat treatment (600°F) for 5 hours.

Instead of briquetting the powdered mixture under high pressure as hereinbefore described, 80 the powder can in suitable cases be shaped prior to sintering by a method in which a mould cavity of the desired shape is loosely filled with the powder, one of whose ingredients (for example, tin) present in relatively small 85 amount has a considerably lower melting point than the copper, and the mould is then heated to a temperature sufficient to melt that ingredient.

The powdered mixture can also be spread on 90 a non-porous metal backing strip, such as a steel strip, so that the powdered metal becomes bonded thereto on sintering. When this latter procedure is used, it is often advantageous to employ a strip having a thin electrodeposited 95 layer of a suitable metal plate on its surface; the strength of the bond is thus increased. After sintering, the composite of spongy sintered copper-base metal on the strip can be rolled to increase the density of the bearing 100 and then resintered or annealed. Additional rolling and annealing treatments can be employed to increase still further the density of the bearing. This procedure is particularly 105 suitable for forming a highly wear resistant sintered copper-base metal bearing layer on a steel backing strip.

The invention can be applied to the manufacture of piston pin bushings, cam shaft bushings, balancer shaft bushings and thrust 110 washers.

Experiments were carried out to compare the wear resistance of sintered bronze containing between 1 and 5% by weight of hard particles of aluminium oxide with the wear 115 resistance of sintered bronze containing no aluminium oxide.

The samples to be examined were prepared by briquetting at a pressure of 60,000 pounds per square inch and sintering for 25 minutes in an atmosphere of dissociated ammonia at 1575°F; the samples were then cooled in this atmosphere. None of the samples was forged.

Specimens were taken from these samples, and each specimen to be tested was machined to 120 prepare a  $\frac{1}{8}$  inch by  $1\frac{1}{8}$  inch rubbing surface. The specimens were then successively locked to a wear test machine and held in contact at their prepared rubbing surfaces with a rotating smooth-surfaced cast iron wheel having a face 125 130

width of one inch.

A wear test using this apparatus was conducted in which the load was increased to 512 pounds and held at this value for a total test period of five hours. At the end of this time, those sintered bronze specimens which did not contain aluminium oxide had lost an average of 0.341 gram, while those specimens containing the hard particles of aluminium oxide showed an average loss in weight of only 0.0426 gram. In addition, while the latter specimens suffered a volume loss averaging only  $11 \times 10^{-5}$  cubic inch, the volume of the test specimens not containing aluminium oxide was reduced on the average by  $269 \times 10^{-5}$  cubic inch.

What we claim is:—

1. Sintered bearing metal which is made by a powder metallurgy process and contains at least 50% by weight of the product and hard particles of aluminium oxide in a proportion between 0.25 and 15% by weight of the product.  
 2. Sintered bearing metal which is made by a powder metallurgy process from a powdered mixture containing at least 50% by weight of copper and containing hard particles of aluminium oxide in a proportion between 0.25 and 15% by weight of the mixture.  
 3. Sintered bearing metal according to Claim 1 or 2, wherein the percentage of hard particles of aluminium oxide is between 0.25 and 7.5.  
 4. Sintered bearing metal according to Claim 3, wherein the percentage of hard particles of aluminium oxide is between 1 and 5.

5. Sintered bearing metal according to any preceding claim, in which the remaining metallic ingredient is substantially all zinc, which is present in a percentage up to 45 by weight.

6. Sintered bearing metal according to any of Claims 1 to 4, in which the remaining metallic ingredient is substantially all nickel, which is present in a percentage up to 49 by weight.

7. Sintered bearing metal according to any of Claims 1 to 4, in which the remaining metallic ingredient is substantially all lead, which is present in a percentage up to 30 by weight.

8. Sintered bearing metal according to any

of Claims 1 to 4, in which the remaining metallic ingredient is substantially all aluminium, which is present in a percentage up to 55 by weight.

9. Sintered bearing metal according to any preceding claim, in which the percentage of copper is more than 70.

10. Sintered bearing metal according to Claim 1 or 2, in which the percentage of copper is more than 70, and in which the remaining metallic ingredient is substantially all tin, which is present in a percentage up to 18 by weight.

11. Sintered bearing metal according to Claim 10, in which the percentage of tin is between 1 and 13.

12. Sintered bearing metal according to Claim 1 or 2, in which the percentage of copper is more than 70, and in which the remaining metallic ingredient is substantially all nickel, which is present in a percentage between 2 and 15 by weight.

13. Sintered bearing metal according to Claim 1 or 2, in which the percentage of copper is more than 70, and in which the remaining metallic ingredients are substantially all tin and nickel together, in percentages respectively between 1 and 13, and 2 and 15, by weight.

14. Sintered bearing metal according to any of Claims 10 to 13, wherein the percentage of hard particles of aluminium oxide is between 0.25 and 7.5.

15. Sintered bearing metal according to Claim 14, wherein the percentage of hard particles of aluminium oxide is between 1 and 5.

16. A bearing having a bearing surface formed of sintered metal according to any of Claims 1 to 9.

17. A bearing having a bearing surface formed of sintered metal according to any of Claims 10 to 15.

18. A method of making sintered bearing metal according to any of Claims 1 to 15, in which a powdered mixture comprising copper-base metal and hard particles of aluminium oxide is briquetted at a pressure between 20,000 and 120,000 pounds per square inch and then sintered in an inert atmosphere at a temperature between 1300°F and 1960°F.

E. WILLIAMSON,  
Chartered Patent Agent.

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